sionally the fog forms as far as 20 miles out at sea, increasing in amount as it comes steadily landward in the form of a high bank or wall. This formation is probably of different origin from that referred to in the preceding paragraphs. It is due no doubt to the upwelling of relatively cold water some distance offshore. The ocean air, already near the point of saturation, is cooled to its dewpoint when it comes in contact with this relatively cold water. The fog then formed persists unbroken for long periods of time. When the air in which this fog floats is drawn inland to replace the heated air rising over the hot interior valleys in summer, this fog, already formed, moves inland with it and does not dissipate until the sun literally dries it up from above. The wind direction naturally determines whether or not fog of this kind comes inland.

A marked case of fog formation and dissipation with relation to the shifting of the wind occurred in December, 1915. On the 20th the temperature on the mountain began to rise slowly. The following morning at 5 o'clock the thermometer recorded almost 1 degree higher than the preceding afternoon. Also considerable fog had formed below at an elevation of about 800 feet. By 5 p. m. the temperature had risen to 54°F., and conditions resembled those usually present during the summer months, the period of greatest fog prevalence below. Early the following morning the wind changed to the northeast, and by mid afternoon the fog had dissipated. At 5 a. m. the next day, December 22, it was observed that some fog had formed during the night. The temperature here was 53°F., while at San Francisco, 14 miles southeast of here, it was 50°F. The wind during the night and up to 7 o'clock in the morning was from the north, when it veered to the northeast. By 8:30 a. m. the fog below had disappeared. The temperature continued to rise, and reached 59°F. in the middle of the afternoon, and was 57°F. at 5 p. m. At San Francisco the temperature at 5 p. m. was 60°F., and had been as high as 64°F. in the middle of the day. No fog formed during that day. Soon after noon the wind backed to the northwest and continued from that quadrant until 9 a. m. of the 23d. At 5 o'clock that morning the temperature on the mountain, which represents the temperature of the upper air, was 56°F., equal to temperatures on many mornings in the middle of summer. At San Francisco the temperature at the same time was 51°F. About half the surrounding country was covered with fog. The wind swung to the northeast at 9 a. m., remaining there till 1 p. m., when it backed to the north. The fog cleared away before noon. The weather remained warm throughout the day, the wind continuing light from the north until 4 a. m. of December 24, when it veered to the northeast, remaining there until 11 a. m. Very little fog formed during the night. At 5 o'clock that morning the temperature here was 54°F., while at San Francisco it was 10 degrees lower. By 3 p. m. a fog bank could be seen about 20 miles out on the ocean, moving landward. Signs of the wind backing to the northwest were noticed at 3:30 p. m. By 5:30 it had gone to the northwest, and by 7 p. m. the direction was west. Also by 5 p. m. the fog had reached the shore and in another hour completely covered the ocean and land to the south and southeast of Mount Tamalpais. The temperature fell during the night of the 24th, being 49°F., at 5 a. m. of the 25th. At San Francisco it was 1 degree warmer. Simultaneously with the return to normal winter temperatures, i. e., warmer at sealevel than at higher altitudes, the fog began to dissipate and was gone by mid-afternoon.

The foregoing case bears out the hypothesis that the temperature of the upper air must be higher than that of the lower to produce proper conditions for fog formation, and also shows the part the direction of the wind plays with regard to fog formation and dissipation.

ON THE SO-CALLED CHANGE IN EUROPEAN CLIMATE DURING HISTORIC TIMES.[1]

By H. H. HILDEBRANDSSON.

[Presented to the Royal Society of Sciences of Upsala, Nov. 5, 1915.]

INTRODUCTION.

It is a well-established fact that climate has undergone very great changes in all the lands of the world during those distant times with which geologists are concerned. Even during the relatively short period that has elapsed since the end of the glacial epoch it has been possible to verify quite considerable variations in the Scandinavian countries. For example, it is well established that since the glacial epoch the climate of Sweden was at one time much warmer than it is to-day. In the peat-bogs have been found hazelnuts or filberts (*Corylus avellana*) as far as Lapland, the *Trapa natans* occurred in the lakes of Sweden up to the latitude of Upsala, and stumps of pine trees are found in the Scandinavian Alps up to the present limits of the birches, etc. These climatic variations are explained by the great changes in distribution of land and sea. It is clear that the climate must have been other than as it is at present when the Baltic occupied the greater portion of southern Sweden, and that it must have been different when this great lake was filled with fresh water than it was at the time when it formed a gulf of the sea filled with salt water. Archæologists find that the peninsula has had almost the same coast line—except the coasts of Norrland—since the beginning of the Iron Age, that is, at a period estimated as preceding our own by 2,500 years. Since that epoch there has been no notable change in the distribution of land and water. It remains to determine whether the climate has undergone a change during this period, i. e., historic times.

This question has been the subject of lively discussion for a long time and in recent years it has become somewhat acute, particularly through the recent researches of O. Pettersson. He seeks to prove that our climate undergoes a secular variation of about 18 centuries, due to a corresponding variation in the heat given out by the sun. This theory has called forth other researches concerning which we shall speak below.

Here I shall endeavor to present the results arrived at by a study of the question. We shall not consider accidental or periodic variations which are well recognized and exist everywhere. In every country there are years, even series of years, which are warm or cold, dry or moist, etc., and several more or less regular periods have been shown to exist, such as that of Brückner, that of solar spots and other shorter ones recently studied by Wallén. *In the present study we shall endeavor to determine whether or not there has been a continuous change in climate in one direction during historic times; in other words, whether the climate of Europe is improving or deteriorating.*

The question would be easily answered if we had continuous meteorological observations from several centuries back down to the present. But even the invention of meteorological instruments goes back scarcely

[1] *Translated from* Nova Acta Regiæ Societatis Scientiarum Upsaliensis, Series IV, v. 4, no. 5, Upsala, 1915. 31 p., 3 pl. 4°.—C. A., jr.

two or three hundred years, and precise observations date from but the beginning of the last century.

Thus we can not have recourse to definite figures or to numerical observations. It is necessary to supplement direct observations by those passages in various authors' works relating to the condition of the crops, the time of the vintage, and a number of natural phenomena such as the freezing of the seas, opening of the rivers in the spring, the northern or southern limits of certain plants, etc.

TESTIMONY OF THE ANCIENTS.

At the outset one must consider what is to be found in this line for the southermost countries. Already Arago[2] had proved that *3,300 years have not brought about any appreciable alteration in the climate of Palestine.* In fact, in order that dates shall come to maturity, the mean annual temperature must be at least +21° C. On the other hand, the vine can not be profitably cultivated: it ceases to yield fruits suitable for the manufacture of wine as soon as this same mean temperature exceeds +22° C. Now, the lower thermometric limit for the date differs very little from the upper thermometric limit for the vine: if then we find that in two different epochs the date and the grape mature simultaneously at any given place, we may affirm that there has been no sensible climatic change during the interval between the two epochs. This is the case, however, in Palestine. The city of Jericho is called the city of palms. The Bible speaks of palms when referring to the earliest times. The Jews ate dates and prepared them as dried fruits; they also extracted from them a kind of honey and a fermented liquor. Pliny, Theophrastus, Tacitus, Josephus, Strabo, etc., also mention palms located in Palestine. *And the culture of the date has not ceased up to the present day.*

The same is true concerning the vine that one cultivated for the sake of wine. The Bible frequently mentions it and Strabo and Diodorus highly praise the vines of Judea. *The culture of the vine has not ceased.* The mean annual isotherm of 21°C. passes through Palestine as Arago predicted.

Arago's result has recently been confirmed in an unexpected manner. In the Mishnah, a collection of religious writings of the first century, they have found recorded measures of rainfall for the first century of our era. These are the first quantitative observations of a meteorological phenomenon which exist. The observations are in perfect accord with modern pluviometric observations at Jerusalem by Thomas Chaplin.[3] It is thus well established that the climate of Palestine has not changed during historic times.

Arago found the same circumstance to obtain for several places in the subtropical zone of the Mediterranean. According to Theophrastus the date palm was planted in Greece, but it bore no fruit there. However, on the Island of Cyprus the date attained to edibility although it did not wholly mature. The small amount of heat which this fruit lacks to-day in order to bring it to perfect maturity on that same island was therefore also lacking in antiquity.

Pliny says that the laurel and the myrtle grew on the Roman campagna. Now this would suppose a mean temperature of at least 13° or 14°C. These temperatures are the lower limits and [not] very far from the actual temperatures to-day. Pliny adds that in his time the laurel and myrtle prospered in middle Italy even up to some elevation on the mountain flanks. To-day these plants do not pass the altitude of 400 m., and from this relation we may conclude, without hesitation, that ancient Rome did not grow sensibly colder than Rome of to-day.

Was Rome warmer? "A passage from Pliny the Younger," says Arago, "leads to a negative reply. He said, in speaking of a field located in Tuscany, 'Laurels occur there; if they sometimes die there, this does not happen more frequently than in the environs of Rome.' Accordingly, at that time the laurels sometimes died in the environs of Rome just as happens to-day also." The temperature of that city can not have been much above that which causes the death of the laurel; that is to say, from 13°C. to 14°C. To-day the temperature of Rome is 15.5°C.

Varro gave the time of vintage as between September 21 and October 23; to-day one finds it on the average at October 2 in the vicinity of Rome.

Finally, Virgil and Pliny both state that the plant *Pinus picea* and the ordinary fir could not support the high temperatures of the plains and that they occurred only on the mountains, just as to-day.

Thus, it is evident *that the climate of Rome is sensibly the same at present as in the time of Christ.*

J. W. Gregory, J. Partsch, and others have proved in the same way that the climate south of the Mediterranean, in Cyrenicia and Tunisia, has not changed since Roman times. The character of the country and its vegetation remain the same as described by Strabo and other ancient authors.

But if the climate of the subtropical zone has not changed during historic times, one may deduce the following very important consequence: *If there has occurred a change in climate elsewhere, in more northern countries, one can scarcely explain this change by variation in the amount of heat given off by the sun.*

We remark that an increase in the amount of heat coming from the sun would not bring about a rise in temperature simultaneously over the whole surface of the earth. The tropical zone would first be the most strongly heated, consequently the evaporation from the ocean would be increased; but if the evaporation increased the rains would also increase. In the temperate and cold zones, however, a rainy season is also a season of low temperature. So, then, if the solar heat increases one will have a positive departure throughout the tropical zone and a negative departure over great expanses of the temperate and cold zones. On the contrary if the solar heat diminishes we need not expect a fall in temperature under the Tropics and a rise above the mean over extensive extratropical surfaces.

To study this question more closely we have calculated the mean temperature of January and of July for the 10 years 1894–1903, and the departures from these means for each year for a large number of stations distributed as well as possible over the earth's surface. We have entered all these departures on maps; the positive departures in red, the negative in black. Almost always the departures of the same sign cover very large areas, and the boundary line between the high and low temperatures ordinarily presents irregular sinuosities.

In Plate I [omitted] is reproduced the maps for July, 1902, and July, 1894. It is evident that in 1902 we have an example of the first case: Positive departures over almost all the tropical zone and negative areas on the north and south; while in 1894 the inverse relation obtains. *But in 1902–3 there was a minimum of sun spots, and in 1894–95 there was a maximum. Now a variation in the*

[2] *Arago.* Œuvres complete. Paris, 1858. t. 8.
[3] *Hellman, G.* The dawn of meteorology. Quarterly jour., Roy. meteorol. soc., London, Oct., 1908, 34: 226. Also published separately.

quantity of heat sent out by the sun makes itself felt particularly in low latitudes. If the climate has not changed, a change in more northern countries can not be explained by a variation in the heat emitted by the sun.[4]

Arago thought that the southward retrogression of the limit of cultivation for the vine in France and England appeared to show that even in the sixteenth century the summers had grown warmer than they are to-day. He adds, however, "I do not attach more importance than it deserves to this latter circumstance. The quality of the wine depends, indeed, too much on the nature of the plant and the care given by the cultivator to permit that it should furnish unanswerable arguments in the question of the change of climate."

This question was the object of a lively discussion at the International Meteorological Congress at Paris in 1899. Mascart summarized the result of the discussion as follows: "One has often alleged the southward retrogression of the limit of culture of the vine. But this fact does not prove anything. At a time when transportation was difficult one contented himself with vines that gave one or two good vintages in 10 years, vintages that one preserved very carefully. The other years gave but a poor drink with which one got along for lack of better and which on the other hand perhaps equaled our artificial wines." [5]

One often cites historic documents to the effect that during some centuries the vine was cultivated even in England and that wine was made there. The first to speak of this is Bede. He says: "Vineas etiam in quibusdam locis germinas" (Hist. Ecclesiast. t.). In the Domesday Book several places are mentioned where the vine was cultivated, thus at Rayleigh in Essex, where in good years the vintage yielded 20 "modii" of wine from a surface of 6 "arpennes." In certain old English books we often find mention of places where the vine was cultivated. Thus, in the time of King Edward II, wine was on sale from a vine at Ely, but in the time of Edward IV this culture had stopped. Even in 1685 Dr. Bathurst, president of Trinity College, Oxford, made from his grapes "as good claret as one would wish to drink." But one is always dealing with *isolated localities*, and Lord Bacon expressly says that "the grapes require a south wall to ripen." But under this condition one can cultivate them even to-day in southern Sweden. I myself have seen the grapes mature at Kalmar when against walls facing south.

It has also been claimed that the mean epoch of the vintage has been retarded. In his great "Étude sur les vendanges en France" Angot[6] has shown that, on the average for almost the whole of France, there is a mean difference of about 11 days between the dates of vintage in two consecutive years, and that the observed difference between the *extreme dates* during a long series of years generally exceeds 60 days. This variation often occurs between years close together. Thus the difference between the dates of vintage of 1816—one of the most tardy years—and of 1822—one of the earliest years—exceeded 40 days throughout almost the whole of France, and amounted to 60 days at Loches, 62 at Chize, and 70 at Vesoul. However, there does not exist any retardation in the epoch of the vintages. It is true that at Dijon, for example, from 1750 to 1850 the grapes were harvested much later—on the average about seven days—than from 1625 to 1725. At Salins the variations are much less distinct and even rather in the opposite sign, for the period 1700–1800 shows an advance of four days over the period 1550–1650. The greatest difference between two periods of a hundred years is found at Aubonne, the vintages between 1575 and 1675 were there made earlier on the average than those between 1675 and 1775.

"This fact," says M. Angot, "have led some authors to infer that there has been a modification, a cooling off of our climate. But one may remark first of all here that these variations do not seem to take on the appearance of a change that would always proceed in the same direction, such a change as would result from a progressive deterioration in the climate; rather they seem to be oscillations. Thus from 1775 to 1875 the mean epoch of the vintage at Aubonne advances by 10 days over that for the preceding secular period, and it is only 3 days behind the epoch that had been recorded two centuries previous. To-day the vintage date at Aubonne has returned exactly to the date for the sixteenth century. The curve for Dijon, Plate II [not reproduced], also shows a marked tendency to descend, a return to the earliest dates of vintage. Therefore it can not be a question of a permanent deterioration in climate. One may even go further and advance the idea that these slow oscillations in the mean epoch of the vintage are not due to even periodic changes in the climate. In fact, the three stations of Dijon, Salins, and Aubonne are sufficiently near together so that long-period variations in climate should run parallel; in any case the variations at Salins ought to be intermediate to those at the two other stations. Now a simple inspection of the three curves is sufficient to assure oneself that not the slighest parallelism exists. Analogous differences occur between stations much closer together; thus at the beginning of the seventeenth century the mean date of vintage at Lavaux was 10 or 12 days earlier than that at Aubonne, which is also located on the border of the Lake of Geneva and only 25 kilometers distant; at present the mean difference between the vintage date of these two stations is but 1 day.

Again, it is certain that in Burgundy the culture of the vine has not varied since antiquity; the nature of the vine stock, the mode of culture, the localities where the grape develops the best qualities have all remained the same as those described by Columelle in his book "De re rustica," and later by the precise documents on the culture of the vine since 1330 at Beaune, and 1430 at Dijon. We also know that since the time of Gregory of Tours—that is to say, since the sixth century, the great wines of Burgundy have been produced on the same hills and the same parts of the hills—that is to say, the intermediate zone. The same vine stocks carried somewhere else, to another climate or even to a slightly different altitude, give products of no longer recognizable character. One must then conclude from this that for at least 10 centuries the climate of France, and of Burgundy in particular, has not changed in any appreciable fashion. The long-period variations in the epochs of the vintages, variations which are dissimilar in very near-by regions, therefore depend not on changes in the climate but on purely local causes, such as slight modifications in the nature of the vine stock or in the mode of culture, a replanting of the vines, increase in the number of stocks, etc.

OPENING OF LAKES AND RIVERS.

From Sweden we have uninterrupted observations of the breaking up of the ice since 1712 at the port of the town of Westerås on the north shore of Lake Mälaren. In Russia

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[4] Further details in: *Hildebrandsson, H. H.*, Quelques recherches sur les centres d'action de l'atmosphére: V. K. Sv. vetensk. Ak. hdlgr., 1914, **51**, No. 8.

[5] Procès verbaux, Congrés météorologique international, Paris, 1889. p. 15.

[6] *France.* Bureau central météorologique. Annales, 1883, I.

Rykatchev[7] has published a memoir on the opening of the Russian rivers. The longest series of these is that for the Neva at St. Petersburg (Gregorian calendar) and for the Dvina (Düna) at Mitau (Julian calendar).[8] The former extends without interruption from 1713 and the latter from 1530, but unfortunately gaps occur particularly at the beginning of the sixteenth and at the end of the seventeenth century. The series is complete from 1709.

Observations are recorded in Tables 1 to 3. These tables show that the time of the opening has varied considerably from one year to the next, and even the 10-year means differ considerably. Thus Lake Mälaren has been free from ice by May 8, on the average, during the time 1803–1812 and by April 14 during 1723–1732; the Neva has been open by April 27 during 1803–1812 and 1843–1852, and by April 26 during 1733–1742, but the average has been April 17 during the decade 1853–1862, while the Dvina (Düna) opened on April 4, 1804–1812, and on March 16 on the average of the 10 observations that we have between 1651 and 1712.

But on taking the means for Lake Mälaren for the years 1753–1822 = 70 years, one finds April 26, while for the years 1823–1892 = 70 years, one finds April 25. Similarly we find for the Neva from 1713–1792 = 80 years, April 9; from 1793–1862 = 70 years, April 8; and 1793–1871 = 79 years, April 10.

For the Dvina (Düna) we have the following table:

1530–1752=106 years............................averaged..March 25
1753–1852=100 years..................................do....March 26

1530–1623=52 years...................................do....March 28
1626–1750=52 years...................................do....March 24
1751–1802=52 years...................................do....March 25
1803–1852=50 years...................................do....March 28

1530–1852=206 years...................................do...March 26

TABLE 1.—*Breaking up of ice on Mälaren at Westerås, 1712–1892.*

[Abstracted from detailed table.]

Years.	Interval.	Means. Date.	Means. Day of year.	Years.	Interval.	Means. Date.	Means. Day of year.
	Years.				*Years.*		
1712–1722	11	Apr. 20	111	1823–1832	10	Apr. 25	116
1723–1732	10	Apr. 14	105	1833–1842	10	Apr. 25	116
1733–1742	10	Apr. 19	110	1843–1852	10	Apr. 28	119
1743–1752	10	Apr. 26	117	1853–1862	10	Apr. 23	114
1753–1762	10	Apr. 21	112	1863–1872	10	Apr. 24	115
1763–1772	10	Apr. 27	118	1873–1882	10	Apr. 30	121
1773–1782	10	Apr. 22	113	1883–1892	10	Apr. 23	114
1783–1792	10	Apr. 29	120	Extremes:			
1793–1802	10	Apr. 24	115	1822	....	Mar. 15	75
1803–1812	10	May 8	129	1881	....	May 20	141
1813–1822	10	Apr. 25	116				

TABLE 2.—*Breaking up of ice in the Neva, 1713–1872.*

[Abstracted from detailed table.]

Years.	Interval.	Means. Date.	Means. Day of year.	Years.	Interval.	Means. Date.	Means. Day of year.
	Years.				*Years.*		
1713–1722	10	Apr. 25	116	1813–1822	10	Apr. 18	109
1723–1732	10	Apr. 19	110	1823–1832	10	Apr. 17	108
1733–1742	10	Apr. 26	117	1833–1842	10	Apr. 22	113
1743–1752	10	Apr. 20	112	1843–1852	10	Apr. 27	118
1753–1762	10	Apr. 18	109	1853–1862	10	Apr. 24	115
1763–1772	10	Apr. 20	111	1863–1871	9	Apr. 26	117
1773–1782	10	Apr. 22	113	Extremes:			
1783–1792	10	Apr. 25	116	1822	....	Mar. 18	78
1793–1802	10	Apr. 18	109	1810	....	May 12	133
1803–1812	10	Apr. 27	118				

[7] Wild's Repertorium für Meteorologie, St. Peterburg, 1887. Supplem. Band II.
[8] Kupfer. Correspondance météorologique, 1852. St. Petersbourg, 1853, p. XXXII.

Thus, in spite of the great variations even in the 10-year means, *the average arrival of springtime has been constant in the Baltic region at least since the beginning of the sixteenth century.* There is little probability that a much more severe climate prevailed during the fourteenth and fifteenth centuries, and in any case we should not have to do with a regular variation.

The objection might be offered: Although the arrival of spring has not varied yet the climate may have become more marine or more continental during the later centuries. Perhaps the winters of the fifteenth century were more severe than at present, although the dates of the opening of rivers have remained the same.

It is easy to refute this objection. As a matter of fact the date of the opening of a stream depends primarily upon the degree of cold of the past winter.

In Table 4 we have entered first the mean temperature at Thorshavn on the Faroe Islands and at Berufjord on the northeast coast of Iceland for the coldest months January–February; second, the means for January–February at Upsala, about 70 kilometers distant from Westerås; third, the day of the year on which the ice went out of the harbor at Westerås. *It is apparent that the departures of the mean temperature at Upsala and of the mean dates at Westerås almost always have opposite signs;* this is particularly the case if the departures are considerable. *A rigorous winter temperature brings a retarded date of opening of the harbor and a mild winter is followed by an early opening.*

Now if the dates of the opening of the river have been constant since the Middle Ages the climate has not grown either more continental or more marine, at least to a sensible degree (see also Plate III, not reproduced).

In my researches on the centers of action of the atmosphere I have proved that the winter temperatures in the Baltic region is determined by the temperature of the ocean between Iceland and Norway. We see from Plate III that with barely three exceptions the departures at Berufjord and at Thorshavn have the same sign as those at Upsala.[9]

But then one must conclude that *if the climate of the Baltic region has not changed the climate of the district about Iceland has also remained constant.*

TABLE 3.—*Breaking up of the ice in the Dvina (Düna), 1557–1852.*

[Abstract from detailed table.]

Years.	Interval.	Means. Date.	Means. Day of year.	Years.	Interval.	Means. Date.	Means. Day of year.
1557–1571 [1]	10	Mar. 26	86	1773–1782	10	Mar. 24	84
1572–1584 [2]	10	Mar. 21	81	1783–1792	10	Mar. 29	89
1585–1594	10	Mar. 28	88	1793–1802	10	Mar. 21	81
1595–1616 [3]	10	Mar. 25	85	1803–1812	10	Apr. 4	95
1617–1650 [4]	10	Mar. 23	83	1813–1822	10	Mar. 23	83
1651–1712 [5]	10	Mar. 16	76	1823–1832	10	Mar. 25	85
1713–1722	10	Mar. 27	87	1833–1842	10	Mar. 24	84
1723–1732	10	Mar. 27	87	1843–1852	10	Mar. 29	89
1733–1742	10	Mar. 20	80	Extremes:			
1743–1752	10	Mar. 25	85	1652	....	Jan. 23	23
1753–1762	10	Mar. 23	83	1659	....	Apr. 22	113
1763–1772	10	Mar. 29	89				

[1] 1559–1561, inclusive, missing.
[2] 1573–1575, inclusive, missing.
[3] 1599–1600, 1603, 1608, 1610, 1611, 1613, 1614, missing.
[4] 1620, 1624, 1625, 1627–1642, 1644–1648, inclusive, missing.
[5] 1654–1658, 1660, 1661, 1663–1666, 1668–1708, inclusive, missing.

[9] For details see: *Hildebrandsson*, Quelques recherches sur les centres d'action de l'atmosphère.

TABLE 4.—*Mean temperature of January and February at Thorshavn and Berufjord and at Upsala, compared with the breaking up of the ice on Mälaren at Westerås.*

Year.	Thorshavn and Berufjord means.	Departure.	Upsala mean.	Departure.	Mälaren opened.	Departure.
	°C.	°C.	°C.	°C.	*Day.*	*Day.*
1875	+1.6	+0.7	−9.0	−4.3	129	+ 1
1876	+1.8	+0.9	−4.7	0.0	118	− 1
1877	−0.2	−1.1	−6.8	−2.1	135	+16
1878	+1.5	+0.6	−2.8	+1.9	107	−12
1879	+0.5	−0.4	−6.8	−2.1	123	+ 4
1880	+2.8	+1.9	−2.3	+2.4	112	− 7
1881	−2.8	−3.7	−9.2	−4.5	141	+22
1882	+1.5	+0.6	−0.7	+4.0	139	+20
1883	+3.0	+2.1	−3.7	+1.0	122	+ 3
1884	+1.5	+0.6	−2.6	+2.1	100	−19
1885	+1.0	+0.1	−3.9	+0.8	114	− 5
1886	−0.6	−1.5	−3.8	+0.9	110	− 9
1887	+2.0	+1.1	−0.3	+4.4	97	−22
1888	−0.6	−1.5	−4.7	0.0	134	+15
1889	0.0	−0.9	−3.5	+1.2	122	+ 3
1890	+2.9	+2.0	−1.7	+3.0	97	−22
1891	+2.5	+1.6	−2.2	+2.5	122	+ 3
1892	−1.2	−2.1	−5.7	−1.0	118	− 1
Means	+0.9	....	−4.7	....	119	....

SUPPOSED CHANGE IN THE CLIMATE OF ICELAND.

It has often been claimed that the climate of Iceland has grown more severe since its colonization, because the forests that once covered the island "from the mountains to the shore" (Fra fjeld til strand) have almost disappeared, while agriculture and cattle raising have greatly fallen off.

However, the Icelander, Th. Thoroddsen, professor at Copenhagen and the greatest authority on his native isle, has recently proved that these changes have resulted from *economic and political causes*—i. e., they are due to man and not to a *change in the climate.*

As for the forests, some of them still remain in the unsettled portions of northern Iceland, but one must observe that in Iceland one still calls the brush of dwarfed birch (*Betula alba*) with scattered examples of *Sorbus ancuparia, Salix phylicifolia*, and *Salix glauca* by the name of forests (Skogar) as in other days, not meaning the tall forests as in Europe. One occasionally finds a birch 6 to 9 meters high in a well-sheltered valley. The "forests" of other days did not have taller trees. In the peat bogs occur fossil trees whose dimensions are as small as those of to-day and the oldest Icelandic annal (Saga, pl. Sagor) mentions persons going to Norway to buy wood from which to build their houses. At the beginning of the eleventh century St. Olaf, king of Norway, granted the Icelanders the right to take wood from the State forests.

If Iceland became depopulated, undoubtedly the shrubbery would re-wood the island, but at present the immense flocks of sheep living in the open air throughout the year devour the buds of the plants as they are beginning to put out. The decrease in forests has therefore nothing to do with the climate.

It has been the same with *the ancient Icelandic agriculture.* The first colonists, accustomed to cultivate the soil, started in immediately with this labor in their new country also; but agriculture met with poor success. Barley (*Hordeum vulgare*) was the only grain sown, as was the custom at that time in northern Norway and still prevails to-day in Swedish Lapland; but generally barley only ripened in very good years. In general, one could not make bread of it, only gruel and beer; but as they had no hops it was necessary to prepare the beer immediately before using it; and it seems to have often happened, as the ancient records relate, that "the beer was bad and the diners remained sober."

In fact, bread was regarded as a *rare luxury*, and the little that one had of it was generally imported. In 1174 the archbishop at Nidaros (Drontheim) received the right to export to Iceland "triginta leste farina." Farina is translated by *miol;* that is to say, the meal of barley in the Icelandic text.[10] The price of "miol" in Iceland was very high in the year 1200. One could buy a good cow or a horse for 104 k. of miol. To take the place of bread the Icelanders ate dried fish (*skreid*). The accounts of the bishop at Holar for the year 1374 show that in that year there had been consumed 8,800 pd. of "skreid," 7,200 pd. butter, and only 60 pd. of flour. Wheat (*Triticum vulgare*) and white bread were extremely rare articles at that time there and when in 1237 the pope forbade the use of barley and beer in celebrating the Holy Sacrament, the bishops of Skalholt obtained a monopoly of importing wheat and wine for the churches.

It is true that barley had been cultivated in Iceland for three or four hundred years, but step by step and to the extent that the imported grain became cheaper—particularly after the beginning of English commerce about the middle of the fifteenth century—its cultivation has diminished and finally has almost ceased. *But the cause of this diminution is purely economic and has nothing at all to do with the climate.*[11]

The great herds of cattle and of sheep are raised on the broad verdant plains. We have seen that much butter was consumed. In fact, every peasant lived from the products of his land and the only things that he had to buy abroad were the wood, iron, and salt, for which he paid in woolen cloth, which was legal tender. But as commerce developed one could secure bread, beer, and many other products, which contributed to make the bill of fare of the peasant more agreeable and his whole life more comfortable. But the cattle, under the very primitive and poor methods of raising, gave products not suited to export, while the wool is greatly sought after abroad, even to-day, and together with fish constitutes the most important article of export. For this reason came the steady decrease in cattle raising, the increasing flocks of sheep in Iceland, and *not at all because of a change in climate.*

As is well known, Iceland's climate is marine. The summers there are cold, about +10°C., andthe winters are not rigorous. But from time to time it comes to pass that masses of floating polar ice extend down to the northern coast of Iceland and, driven by the current from west to east, drift down to its east coast. Under those circumstances the whole northeastern portion is blockaded by the ice and on rare occasions the polar ice even extends to the south coast. Such a blockade by the ice always brings in its train a very cold season. The sheep, which as we have just seen always live in the open, then die in great numbers and if the ice remains until spring or even into the summer a famine results. According to the ancient records, it has several times happened that men have died of starvation by the hundred, and it has even come to pass that the aged or the invalid were put to death in order to escape the necessity of feeding them. Every Icelander knows that a year of dearth is caused by a more or less severe blockade of the coast.

It appears that the average position of the polar ice has not changed in the vicinity of Iceland since the date of the first description of that country, for which we are indebted to the monk Deeuilus, who lived about the year 825. He says that *the sea about Iceland is generally open,*

[10] Wheat flour is *hveiti* or *flur* in Icelandic.

[11] It is thus with Icelandic agriculture as it is with the grape culture of northern France.

"but on sailing for a day toward the north one meets the frozen sea." This is in perfect accord with what one experiences to-day during those years when there is no ice blockade. One generally meets the edge of the ice at a distance of one day's travel (in the boats of those times) north of Cape Langanes.

Pettersson says that in earlier times it would seem that the ice blockades of Iceland were less severe than they are to-day, since the phenomenon is rarely described in the oldest annals, although very frequently after the end of the thirteenth century. Thoroddsen replies that this is for the simple reason that the annual records begin only at the end of the thirteenth century. The ancient records, the "sagor," describe the life and customs of the distinguished families. Nevertheless, one often meets therein with accounts of years of dearth, horrible famines, rigorous winters, etc.: in other words, the *ordinary results of the ice blockades*. Also they frequently speak of the white polar bears which visited Iceland only across the ice. Their numbers must have been rather large, because the church inventories often mentioned the skins of the white bears on which the priests kneel before the altar in winter.

One of the first colonists, Flokivilgerdarson, looking from the summit of a mountain in the spring of 865 A. D., saw the fjords on the northwest filled with ice, and for this reason he named the new country *Islande*, i. e., the land of ice. But in that year the ice blockade must have been very widespread for it is only in such a case that the northwestern fjords are filled with ice.

Thoroddsen has found in the old annals the description of eight years of famine during the tenth century and of six during the eleventh. But here it is a case of extraordinary famines only, when "men die by the hundreds," "when they ate foxes and crows," "when they killed the old and the weak," etc. The end of the twelfth century and the beginning of the thirteenth was a period during which famines were of terrible frequency. According to Pettersson, of the 58 years, 1291–1348, at least 29 must have been years of dearth, but Thoroddsen remarks that this is an error. According to the registers there were 43 years of average yield, 12 years of dearth, and 3 very good years. During this period there also occurred volcanic eruptions a number of times and also earthquakes, but these phenomena have nothing to do with the climate. According to him, without doubt the fourteenth century brought severe periods, but it was exceeded in this respect by the seventeenth century.

Thus, as we have seen when studying the breaking up of the rivers, we here find again severe periods alternating with warm ones,[12] but one can not demonstrate a change in climate.

SEVERE WINTERS AND FREEZING OF THE SEAS.

There are numerous accounts of severe winters and of freezing of the seas from antiquity down to the present.[13] Capt. C. I. H. Speerschneider, of the Royal Danish Meteorological Institute, has long been studying all accounts of these phenomena in Danish waters which he has been able to find, and has recently published the results of his researches in a very interesting memoir. * * *[14]

After having spent several years studying and critically discussing the details of the recorded conditions of the winter ice in the waters about Denmark, Capt. Speerschneider has drawn up the following table (Table 5) of severe winters during which some portions of these waters have been filled with ice.

[12] Often there is a whole series of years when the Icelandic coasts are relieved of the ice blockade, e. g., 1841–1854 and 1903–1910 in our times.

[13] One of the largest of these compilations is that by Baron Ehrenheim in his farewell address before the Academy of Sciences at Stockholm in 1824, viz, Om Climaternas rörlighet (The variations of climates).

[14] *Speerschneider, C. I. H.* Om isforholdene i Danske farvande i eldre of nyere tid. Aarene 690—1860. (Danish Meteorol. Instit., Publication, Mitt. 2.)

[This paper was abstracted in this REVIEW, May, 1915, 43: 236, and its contents need not be here repeated.—C. A., Jr.]

TABLE 5.—*Severe winters in Danish waters.*

XI.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.
					1601			1901
			1402				1802	
							1803	
							1804	
							1805	
		1306						
				1507				1907
			1408		1608			
						1709	1809	1909
					1610			
							1811	
								1912
							1813	
							1814	
					1615	1715		
						1716		
					1619			
		1320			1620		1820	
			1421		1621		1821	
					1622			
		1323	1423				1823	
				1524				
			1426			1726		
							1827	
			1429		1629		1829	
							1830	
			1431				1831	
					1632			
		1333?						
				1536				
					1637			
							1838	
		1340				1740		
							1841	
							1844	
							1845	
		1346		1546				
1048				1548?			1848	
		1319						
						1751 •		
					1652			
							1853	
					1655	1755		
		1357						
		1358	1458		1658	1758	1858	
					1659			
	126?		1460			1760	1860	
	(?)						1861	
	(?)							
	(?)				1663	1763		
	(?)							
					1665	1765	1865	
					1667	1767	1867	
						1768	1868	
				1569				
					1670	1770	1870	
				1571		1771	1871	
				1572		1772		
				1573				
					1674	1774		
							1875	
						1776		
					1677	1777		
							1879	
							1880	
							1881	
				1583				
					1684	1784		
						1785		
	1286			1586		1786	1886	
				1587				
						1788	1888	
				1589		1789	1889	
				1590				
				1591			1891	
				1592		1792		
				1593			1893	
		1394						
				1595	1695	1795	1895	
	1296							
					1697		1897	
					1698			
		1399		1599		1799		
						1800	1900	

The series is complete since 1750 down, and during this period we have had severe winters as follows [in Denmark]: 1750–1799, 22 times; 1800–1849, 21 times; 1850–1899, 21 times.

Table 6 shows how many years have been marked by floating ice and how many years have permitted traffic on the ice in the different portions in the Danish waters.

TABLE 6.—*Number of years with floating ice (column I) and with traffic upon the ice (column II) in Danish waters.*

Century.	Cattegat.		Le Sund.		Gr. belt.		L. belt.		Femern belt.		Baltic.[1]	
	I	II	I	II	I	II	I	II	I	II	I	II
Fourteenth	1	....	2	....	2	......	1	......	6	5	......	([2])
Fifteenth	3	....	3	2	2	......	......	......	6	4	3	1
Sixteenth	......	....	12	3	4	3	2	......	3	3	1	......
Seventeenth	3	....	16	9	10	3	6	3	5	2	3	1
Eighteenth	9	....	33	13	23	3	11	6	6	1	3	1
1800–1850	7	....	19	9	28	1	9	3	6	......	5	1

[1] This refers to the northern part of the Baltic between Denmark and Germany.
[2] According to Olaus Magnus, one traveled across the ice of the Baltic between Germany and Denmark in 1323 and 1399, years also cited in Speerschneider's table of severe winters, pp. 63 and 65.

Since 1750, when we have continuous observations, the number of severe winters in a 50-year period have remained constant at 20 to 22. Previous to that time observations grow fewer and fewer for each century preceding. Now it is impossible to prove whether the number of severe winters has increased, decreased, or remained constant since the fourteenth century. However, traffic on the ice in the Baltic is so rare an event that it probably would have been recorded. According to this, it would seem that this event occurred once in a century.[15] Speerschneider has also found observations on the appearance and disappearance of ice in the Danish waters. He has found as follows:

Dates.	Number of years.	Began.	Ended.	Days.
1296–1750.	21	Jan. 20....	Mar. 23....	56
1763–1860.	98	Jan. 25....	Mar. 19....	54

It is therefore probable that the frequency, the duration, and consequently also the amount of ice has been constant since the thirteenth century.

The frequently exaggerated accounts of formidably severe winters during the Middle Ages have caused nearly all students in the northern countries, from the time of von Ehrenheim down to Pettersson and Ekholm, to admit that the winters have been much more rigorous in the past with a maximum cold in the fourteenth century. Pettersson seeks to explain the more frequent freezing of the Baltic in those times by hydrographic phenomena. Hydrographic researches—excellently organized in large part by himself—have shown that the salt water of the Kattegat intermittently invades the Baltic through the Sund and the Belts, where it rolls along the bottom and fills the deepest parts. Upon this layer of specifically heavy water rests the upper less salty water of the Baltic. One may often catch fish from the Kattegat even in the shallow strait between Kalmar and the island of Öland. It is sufficient to admit that the straits between the Kattegat and Baltic have been only a few meters deeper[16] in order to bring about a more marked exchange of water between the two seas. Now the level of the salt water in the Baltic would have to rise and the depth of the upper layer would have to decrease. It is evident that under such circumstances the Baltic would freeze over more readily than at present.

[15] It would have been possible in 1893 to cross the Baltic on the ice, had not modern steamers kept wide channels open.
[16] He has studied the Danish marine charts, but the oldest of the seventeenth century still show the same depths in the Sund as are found to-day.

In support of this hypothesis Pettersson cites the Hanseatic herring fisheries in the Sund and southern Baltic. But it seems not improbable that in a time when transportation was difficult one was satisfied with a yield less good, as was the case with the vintages of northern France and the barley of Iceland. In fact, the true herring *Clupea harengus* (Swed. *sill*) to-day is taken only in the southernmost part of the Kattegat[17]; but there is a variety in the Baltic, *Clupea harengus var. membras* (Swed. *strömming*). This variety is smaller than the true herring and becomes yet smaller progressively as the water northward grows less salty. There are still great fisheries of *strömming* throughout the Baltic even into the Gulf of Bothnia. On the southern coast of Sweden this fish grows larger and they call it the *sill*. The *sill* of Blekinge is even famous as an excellent one. Was it perhaps the Baltic herring which the Hansas caught?

Finally, Norlind has recently remarked[18] that these fisheries began 200 years before and finished shortly after the beginning of maximum cold mentioned by Pettersson.

Pettersson has also pointed out that during the 13th and 14th centuries there were frequent storms and invasions by the sea along the east and south coasts of the North Sea where the dykes were destroyed and large portions of the cultivated land devastated. Norlind remarks that the construction of dykes was initiated at the beginning of the 13th century. It is therefore natural that at that time one did not understand how to construct sufficiently strong dykes; gradually the inhabitants have learned how to give them the necessary power of resistance, and so these catastrophes have become more rare. "So it is not at all necessary to hunt for the causes of these catastrophes in climatology, but rather in anthropogeography."

Speerschneider and Norlind both reached the same result, viz, *there was no period of climatological catastrophes* (Klimatologisches Katastrophenzeiten) *in the 14th and 15th centuries and the climate of the Middle Ages was sensibly the same as that of to-day.*

METEOROLOGICAL JOURNAL OF TYCHO BRAHE, 1582–1597.

In 1876 the meteorological committee of the Royal Academy of Sciences at Copenhagen published the meteorological journal maintained by Tycho Brahe from 1582–1597 at his famous observatory Uranienborg on the island Hven in the Sund.[19] These observations embrace all the meteorological observations that one can make without instruments, the latter not having been invented in those times, viz, the amount of snow, days with rain, with snow, with fog, with grésil or with hail, direction and velocity of the wind, hoarfrost [gelée blanche], thunderstorms, auroras, solar halos, remarks on the ice in the Sund, etc. The Danish edition closes with a résumé by Paul la Cour, wherein he compares the annual variations of the various meteorological elements com-

[17] Sometimes the true herring descends into the Sund, as in September, 1915, when they were caught there, but this is of rare occurrence.
[18] *Norlind, Arnold.* Till frågan om det historiska klimatet, särskilt i Nord- och Mellaneuropa. Ymer, 1915, p. 94.
Norlind, Arnold. Einige Bemerkungen über das Klima der historischen Zeit nebst einem Verzeichnis mittelaltlicher Witterungserscheinungen. Lunds universitets årskrift. N. F. Afd. 1, Bd. 10, no. 1.
[19] Tyge Brahes meteorologiske Dagbok, holdt paa Uranienborg for Aarene 1582–1597 Kjöbenhavn, 1876. (Acad. roy. d. sci., Commit. météorol. App. aux Collectanea Meteorologica.)

puted from Tycho's observations, with those found at Copenhagen and other Danish stations during the past century. Ekholm made, in 1899, a similar comparison between the observations by Tycho and those for 1881–1898 at the Swedish meteorological station erected on the spot occupied by Uranienborg.[20] The latter have shown that there the climate of the spring and the autumn has remained constant since the time of Tycho. Ekholm has found, in fact, the following result:

Dates of first and last frosts at Uranienborg then and now.

Years.	Last frost in spring.	First frost in autumn.
1582-1597	April 18	October 27
1881-1898	April 19	October 28

This confirms the result reached by us above in discussing the breaking up of the river ice.

Paul la Cour, however, found a difference in the winds of 1582–1597 and those of our times. The prevailing wind, to-day from the southwest almost throughout the year, was generally from the southeast in those days, specially in winter. Ekholm remarks with reason, that the winters must have been colder then than they are to-day. In fact a southeast wind in winter on the Sund signifies a high pressure over northern Sweden and a low pressure over northern Germany. Now, barometric depressions in those times passed farther south than they do to-day, particularly in the winter time. Such a pressure distribution always occurs during cold winters. It has been supposed that this wind régime, which is so different from that of our day, was simply due to bad exposures of the vane. Such a supposition is altogether improbable in the case of observations made in the most illustrious observatory of the time. It is easy to convince oneself that the observations are accurate. From the observations published in the journal from January to March we have calculated the number of winds from each compass point for the very cold winter of 1595 and the very mild winter of 1588. The winter of 1593 was very mild up to February 15, but very rigorous in March. We have separately computed the wind from January 1 to February 15 and from March 1 to 31 in that year. The results are given in Table 7.

TABLE 7.—*Frequencies of winds from respective directions at Uranienborg.*

Year.	SE.	E.	NE.	N.	NW.	W.	SW.	S.
1595	25	11	30	16	22	12	21	10
1588	8	8	8	10	18	26	14	5
Jan. 1-Feb. 15, 1593	5	2	3	0	5	9	13	4
March, 1593	7	15	6	0	1	0	0	0

Thus one sees that the easterly winds predominated during the severe winters and the westerly winds in the mild winters, just exactly as to-day. It is therefore well established that the winters 1582–1595 were in general more severe that the winters of to-day.

But this does not justify one in concluding that the winters of the sixteenth century were colder in general than those of the past century. In fact one sees from Table 5 that the sixteenth century had 19 severe winters, when the Danish waters were filled with ice; but of these 19 cold winters 9 occurred between 1582 and 1597. This proves that that period was a cold one as was the period from 1802–1812, which caused the late breaking up of the rivers as we have seen above.

So the observations of Tycho Brahe do not permit us to establish any change in climate.

GLACIERS.

The Alpine glaciers are known to be subject to periodic variations. During a series of years they advance in the valleys. The glacier pushes before it its frontal moraine and at times prolonging itself beyond measure invades pastures, overturns forests and buildings. Finally it halts and after a rest it retreats toward the high valleys during a new series of years. We also know that the advance and retreat of a glacier does not depend upon the amount of snow that falls during the winter nor the high temperature of the summer during the preceding year. The mass of snow added to the glacier during a single winter and the heat of a single summer which causes its melting and ablation, do not suffice to produce a noticeable effect. "The determining factor in the variations in length of the glacier," says M. Forel,[21] "is not ablation but the speed of movement of the ice." The relative length of a glacier depends on the relative value of these two simultaneous processes, the motion of the river of ice and the melting of the ice. Of these two factors the melting is subject to annual and irregular variations. This essentially irregular factor would not be the one which occasioned variations of such long periodicity and also of such uninterrupted periodicity as those that we observe in glaciers. But it has been found that the speed of motion varies with the thickness of the glacier; and this is determined by the depth of the névé just as the water of the river increases or diminishes according to the discharge at its source. The névé is formed by the sum of the layers of snow fallen during the preceding years and accumulating one upon the other. In accumulations of this nature there are variations of long period, for, as we have pointed out above, there are series of years when the temperature, or the amount of rainfall or snowfall, is greater or less than the normal. So that it suffices, as a cause of the variation in the length of the glacier, to hunt for variations in the depth of the upper part of the glacier, variations continuing in the same direction throughout long periods of many years. Heim [22] has very properly called a glacier a *climatometer*.

All the Swiss glaciers show movements generally of the same sign.[23] However, the smallest glaciers and those having an abrupt slope begin to advance, and to retreat, somewhat earlier than the large ones. Consequently it happens in certain years that the movements of two glaciers are of opposite sign. But we may not go into more detail here regarding the glaciers. The only question that interests us at present is: Has there been a change in the extent of the glaciers in historic times? All students that have considered this question agree that *in the Middle Ages the extent of the Alpine glaciers was less than it is to-day, but that toward the middle of the sixteenth century they began to advance in a disquieting manner.* This is well proved. For example, Polybius mentions gold and silver mines

[20] Ymer, 1899.

[21] *Forel, F. A.* Essai sur les variations périodiques de glaciers. Arch. d. sci. phys. et nat., Genève. 1881.

[22] *Heim, A.* Handbuch der Gletscherkunde, p. 500.

[23] According to Heim one does find such a parallelism between the movements of all the glaciers of Europe and Asia.

in the Hohen Tauern that were still exploited in the Middle Ages. But at the middle of the sixteenth century all the workings were covered by a glacier. In 1570 the sheet of ice had a depth of 25 meters, which increased to 100 meters during the eighteenth century and then decreased. About 1880 the depth was only 40 meters and later during periods of retreat it has come to pass that the débris of wrecked buildings have reappeared after having been interred in the ice almost 400 years.

According to the record of the church at Grindelwald there was an almost uninterrupted series from 1539 to 1563, of winters with very little snow and often very warm summers. From 1565 to 1580, on the other hand, there was a period of very snowy winters. Thus in the middle of the century or about 1540 there commenced a period of extreme regression, during which the lower glacier of the Grindelwald did not pass the upper rocks (die obern Flühe), while from 1565 on the névés have been increasing. In 1580 the glacier began to pass beyond the rocks and to descend into the gorge; in 1584 the chapel of Sainte-Pétronelle was overturned,[24] and in 1588 a barn was destroyed; in 1593 the glacier reached to the village, invaded two chalets and a large number of barns, and shifted the bed of the Black Lütschine and of the Bergelbach. A road between Oberwallis and Grindelwald was buried beneath the ice. During the great retreat of the glaciers from 1860–1880 portions of this road were seen to reappear.[25]

According to Heim *it is not possible to say whether we are approaching a new glacial period or whether we have to do with a long secular variation in the glacier movements.*

THE REMAINS OF ANCIENT FORESTS IN SWEDEN.

Some botanists have maintained that Sweden's climate has grown colder because to-day forests occur only on the Scandinavian Alps while one finds the evident remains of forests that have been destroyed. In fact the researches in Swedish Lapland along the eastern slopes of the Scandinavian Alps, and particularly those by Gavelin,[26] have proved that rather recent remains of dead trees are to be found almost everywhere above the upper limit of the conifers. *It is particularly the pines* (*Pinus sylvestris*) *that have perished;* the remains of the spruce (*Pinus abies*) or of the birches are rather rare.

But observations have also shown that forests often spring up again. The truth probably is that the forests along their limit of vegetation, increase during a certain number of years, following which another series of years with excessive cold kills them off. Then after a new series of years with mild winters they again begin to grow up.

But higher up in the region of birches and even above it we find in the swamps and bogs quantities of subfossil pine probably dating from the "Atlantic and subboreal period" of Sernander during which the temperature was so high that hazel nuts matured in Lapland. From this time also probably date the oaks buried in the sandy shores of the Clara River in Vermland which one often finds there buried at a depth of 2 to 4 meters beneath the surface of the soil in localities much farther north than the present limit of the oak.

We will not here go into further details concerning these interesting questions to which a final answer has not yet been found.

[24] According to an unverified tradition the bell dated from 1044 A. D.

[25] For further details see *Heim*, op. cit., p. 512–516.

[26] *Gavelin, Axel.* Trädgränsförskjutningarna inom Kamajokks vattenområde (Lilla Lule älf.). Sveriges Geologiska Undersökning, Årsbok, 1909, 3, no. 10.

CONCLUSION.

Our researches have led to the result that there exist everywhere climatic variations of long and short duration, but it is not possible to prove that the climate of Europe has changed for either better or worse during historic times.

P. S.—"As I am closing these researches [last signature was printed Dec. 14, 1915] I am in receipt of the interesting memoir by Prof. J. W. Gregory "Is the Earth Drying Up?"[27] which contains a criticism of the theories put forward by Prince Kropatkin and Prof. Ellsworth Huntington that our earth is steadily growing drier and drier. Gregory's researches have led him to the same result I have reached. "One fact," he says, "does seem to me to result clearly from the evidence; there have been many widespread climatic changes in late geologic times, while in historic times there has been no world-wide change of climate."

VIOLENT EASTERLY WINDS AT TATOOSH ISLAND, WASH.

By RALPH C. MIZE, Observer.

[Dated: Weather Bureau, Tatoosh Island, Wash., Mar. 18, 1916.]

Wires and shrubbery on Tatoosh Island received a heavy coating of ice during the prevalence of a strong easterly breeze on the early morning of February 1, between easterly storms. The rigging of the radio station was covered with from ¼ to ¾ inch, varying with elevation from ground level to 250 feet above, and the aërial was torn away by the excessive weight of the ice. Thawing extended, during the day, to a height of approximately 75 feet, but the coating on the upper 175 feet was not appreciably diminished until it was cracked by the swaying of the cables, and torn loose by the unusual violence of the east-northeast storm of February 2. Flying fragments of ice made travel dangerous in the vicinity of the radio station and the Weather Bureau station throughout that day and night; and the fragments broke all the easterly windows in the Weather Bureau building. The barograph record shows false rises of 0.04 to 0.10 inch from 4:50 p. m. (when the office window broke) to about 7:30 p. m. when the window was boarded up (see fig. 1).

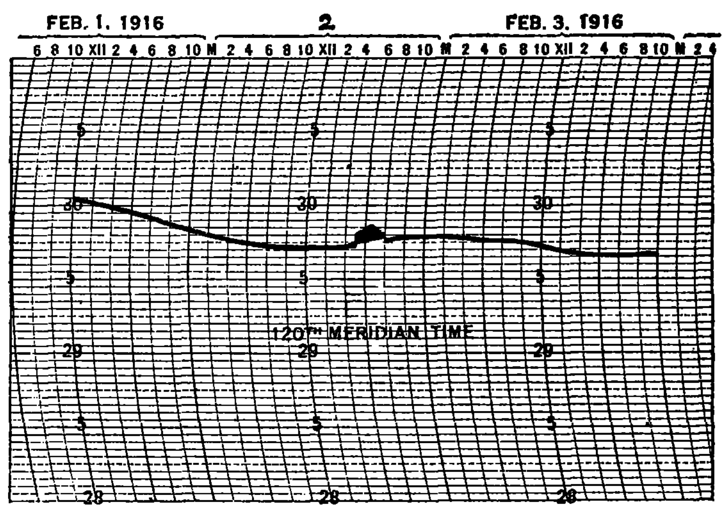

FIG. 1.—Barogram for Feb. 1-3, 1916, at Tatoosh Island, Wash., showing false rises on the 2d (4:50–7:30 p. m.), due to broken window.

[27] *Gregory, J. W.* In The Geographical Journal, London, 1914, 43: 293–318.